

# Bio-Economic Models Prioritizing Mauka Catchment Basins of the East Maui Watershed for Protection Against Miconia Invasion.



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## Mission and Approach:

Design cost-effective management decisions to protect the mauka catchment basins in the East Maui Watershed (EMW) against incipient miconia incursions.

This project will customize bioeconomic intervention models for optimal mitigation of miconia encroaching the EMW mauka catchment basins

The BE model is informed by: (i) species biology and (ii) empirically-derived operational (cost) metrics.

This is a pre-emptive approach deploying a state-of-the-art surgical “weed-ectomy” intervention system to efficiently maintain the long-term health of Haleakala.

## Biological Traits of *Miconia calvescens* DC)

- An autogamous (self-fertile) species
- High fecundity
- Edible to broad range of frugivores
- Long dispersal range
- Persistent seed viability

*Meyer 1998, Murphy et al. 2008*

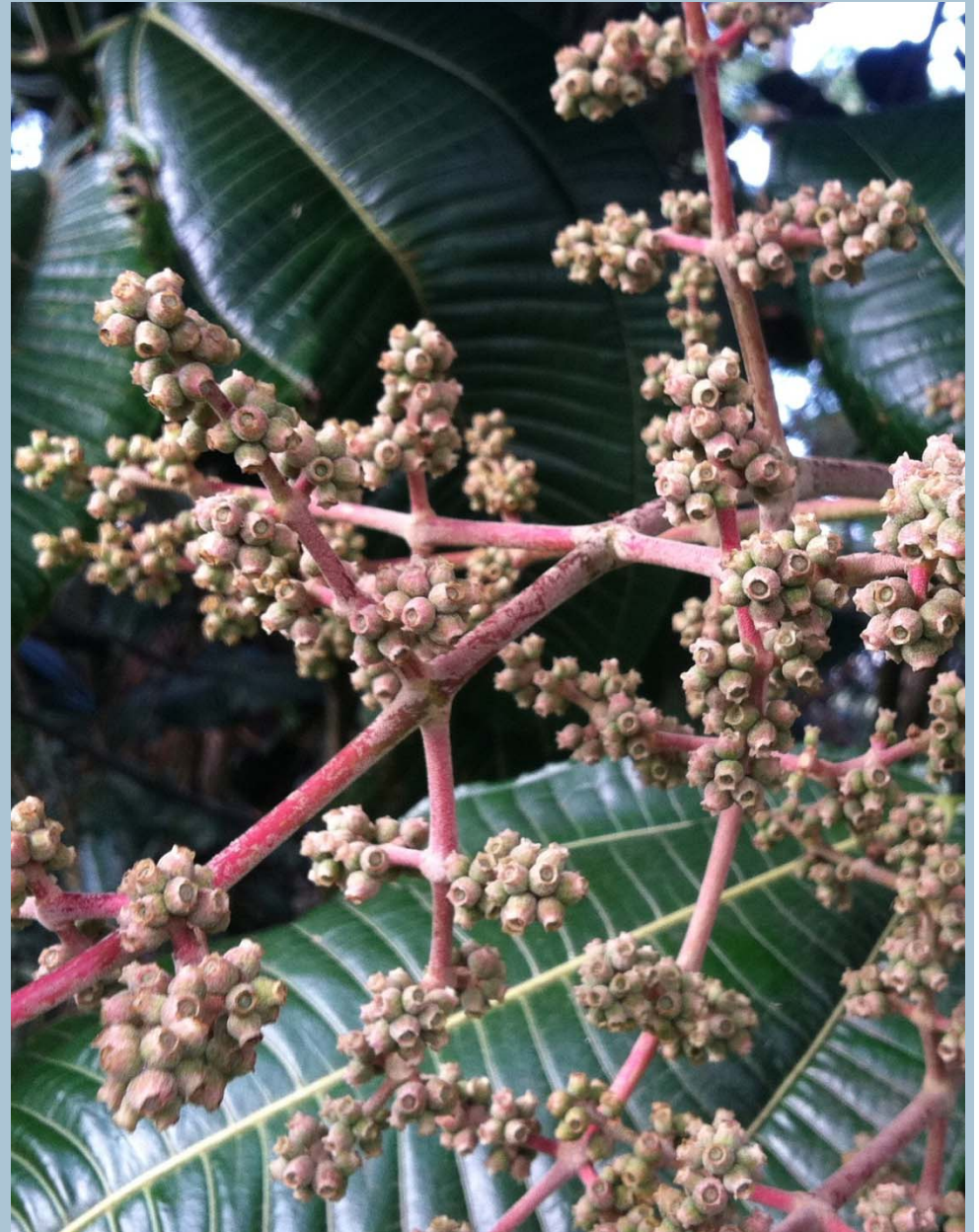
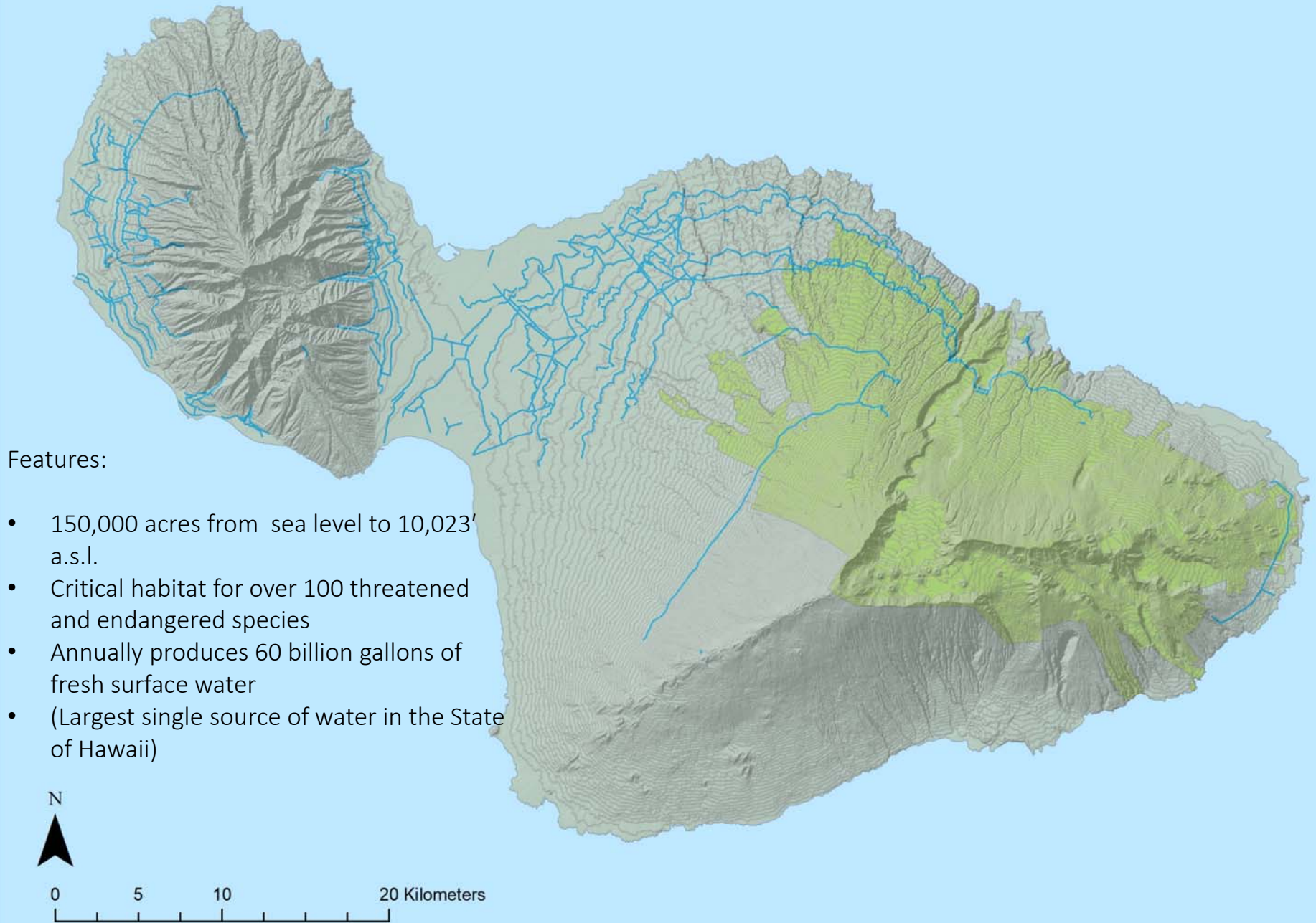


Photo: F. Starr

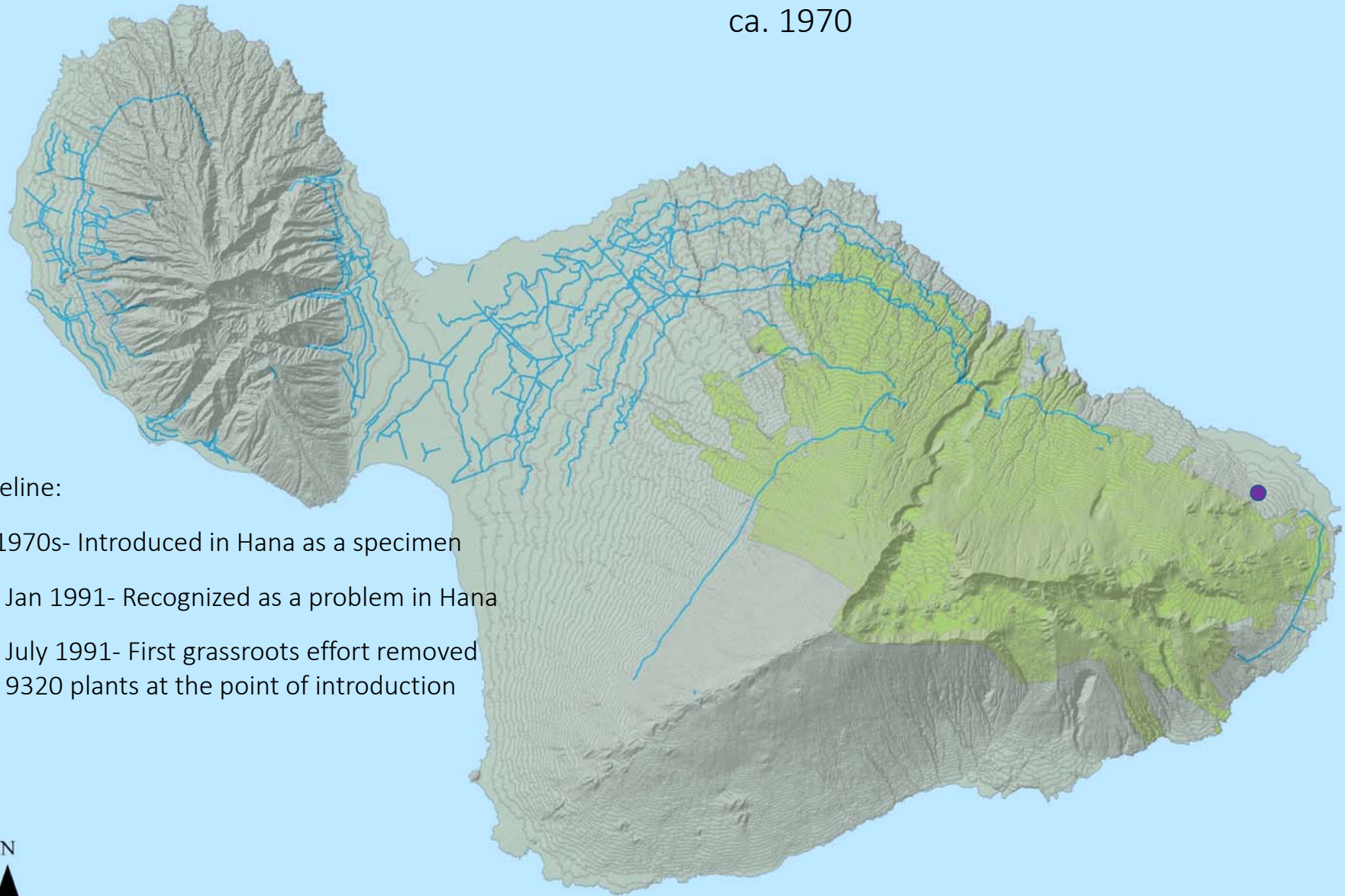
## East Maui Watershed ([eastmauiwatershed.org](http://eastmauiwatershed.org)):



### Features:

- 150,000 acres from sea level to 10,023' a.s.l.
- Critical habitat for over 100 threatened and endangered species
- Annually produces 60 billion gallons of fresh surface water
- (Largest single source of water in the State of Hawaii)

## Invasion History of Miconia in the East Maui Watershed ca. 1970



### Timeline:

- 1970s- Introduced in Hana as a specimen
- Jan 1991- Recognized as a problem in Hana
- July 1991- First grassroots effort removed 9320 plants at the point of introduction



## Invasion History of Miconia in the East Maui Watershed 1991-2011 (n=981,630)

### Timeline:

- 1970s- Introduced in Hana as a specimen
- Jan 1991- Recognized as a problem in Hana
- July 1991- First grassroots effort removed 9320 plants at the point of introduction
- 1991-2011- A comprehensive eradication strategy deployed (n=981,630)

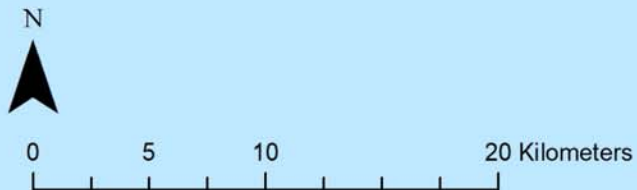




Photo: J. Atwood

Herbicide Ballistic Technology (HBT) targeting Miconia (*Miconia calvescens*)

## Herbicide Ballistic Technology (HBT)

**Concept:** Encapsulated 0.68 caliber herbicide-filled projectiles pneumatically delivered to treat isolated plant populations >>> *LONG DISTANCE ACCURACY (20-30 m) WITH FULL TILT TRAJECTORY (0-90°)*

**Problem:** Incipient populations of miconia are colonizing remote sections of class I watersheds on Maui. Average slope of terrain >50% >>> *AREAS INACCESSIBLE TO GROUND MANAGEMENT*

**Objective:** Detect and eliminate incipient populations >>> Effectively contain the spread of Miconia in the East Maui Watershed.







**FIFRA Sec 24(c)  
Special Local Need**

**ACCEPTED**

January 30, 2012

Under Hawaii Pesticides Law  
as Supplement to Product No.  
9786,263

# HBT-G4U200 With Garlon® 4 Ultra

**FOR DISTRIBUTION AND USE ONLY WITHIN THE STATE OF HAWAII**

FOR INDIVIDUAL PLANT TREATMENT WITHIN FORESTED WATERSHEDS AND NATURAL AREAS  
USING SPHERICAL POLYSACCHARIDE CAPSULES CONTAINING GARLON®4 ULTRA

**ACTIVE INGREDIENTS:**

Triclopyr: 3,5,6-trichloro-2-pyridinyloxyacetic acid, butoxyethyl ester..... 10.07%

**OTHER INGREDIENTS** ..... 89.93%  
..... 100.00%

EPA SLN No. HI-120001

EPA Est. No. 86199-MI-001

**This label must be in the possession of the user at the time of pesticide application.**

**KEEP OUT OF REACH OF CHILDREN  
CAUTION/PRECAUCION**

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand this label, find someone to explain it to you in detail).

FIRST AID	
If swallowed:	<ul style="list-style-type: none"> <li>•Call a poison control center or doctor immediately for treatment advice.</li> <li>•Have person sip a glass of water if able to swallow.</li> <li>•Do not induce vomiting unless told to do so by a poison control center or doctor.</li> <li>•Do not give anything by mouth to an unconscious person.</li> </ul>
If in eyes:	<ul style="list-style-type: none"> <li>•Hold eyes open and rinse slowly and gently with water for 15-20 minutes.</li> <li>•Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.</li> <li>•Call a poison control center or doctor for treatment advice.</li> </ul>
If on skin or clothing:	<ul style="list-style-type: none"> <li>•Take off contaminated clothing.</li> <li>•Rinse skin immediately with plenty of water for 15-20 minutes.</li> <li>•Call a poison control center or doctor for treatment advice.</li> </ul>
If inhaled:	<ul style="list-style-type: none"> <li>•Move person to fresh air.</li> <li>•If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible.</li> <li>•Call a poison control center or doctor for further treatment advice.</li> </ul>
HOT LINE NUMBER	
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact CHEMTREC (800-424-9300)	

**PRECAUTIONARY STATEMENTS**

**HAZARDS TO HUMANS AND DOMESTIC ANIMALS**

**CAUTION:** Harmful if swallowed, causes moderate eye irritation. Avoid contact with eyes or clothing. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.



0.68 caliber soft gel projectiles  
encapsulating 200 mg triclopyr

## HBT SD heliops



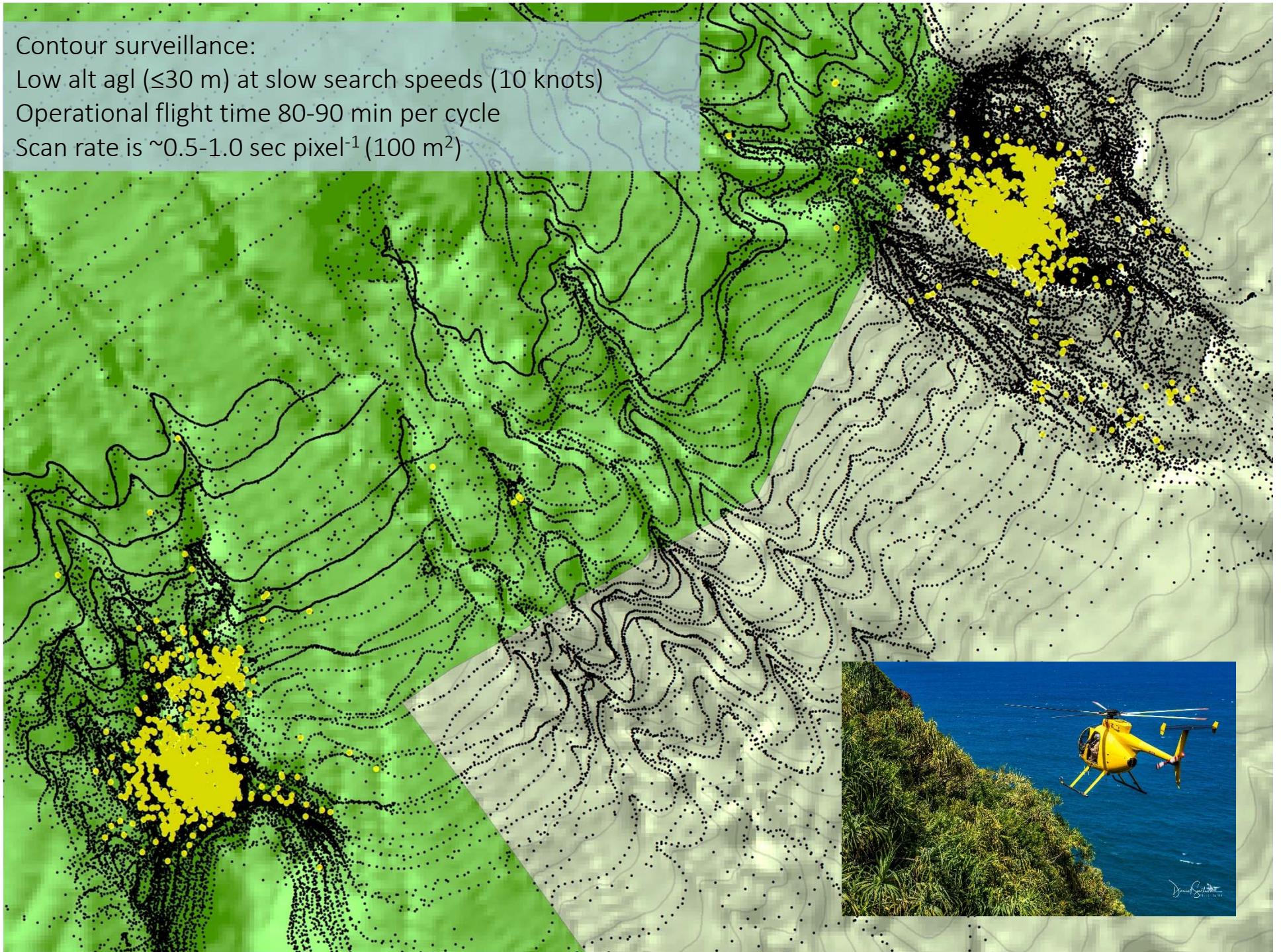
HBT operations conducted with a Hughes 500D helicopter  
Payload Operator "Applicator" portside behind Pilot with shared 8-12 o'clock field of view (FOV)  
Navigator front-starboard for 12-3 o'clock FOV and hazard awareness

Contour surveillance:

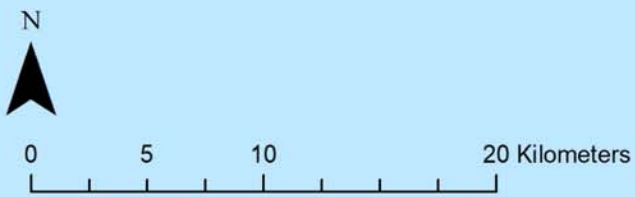
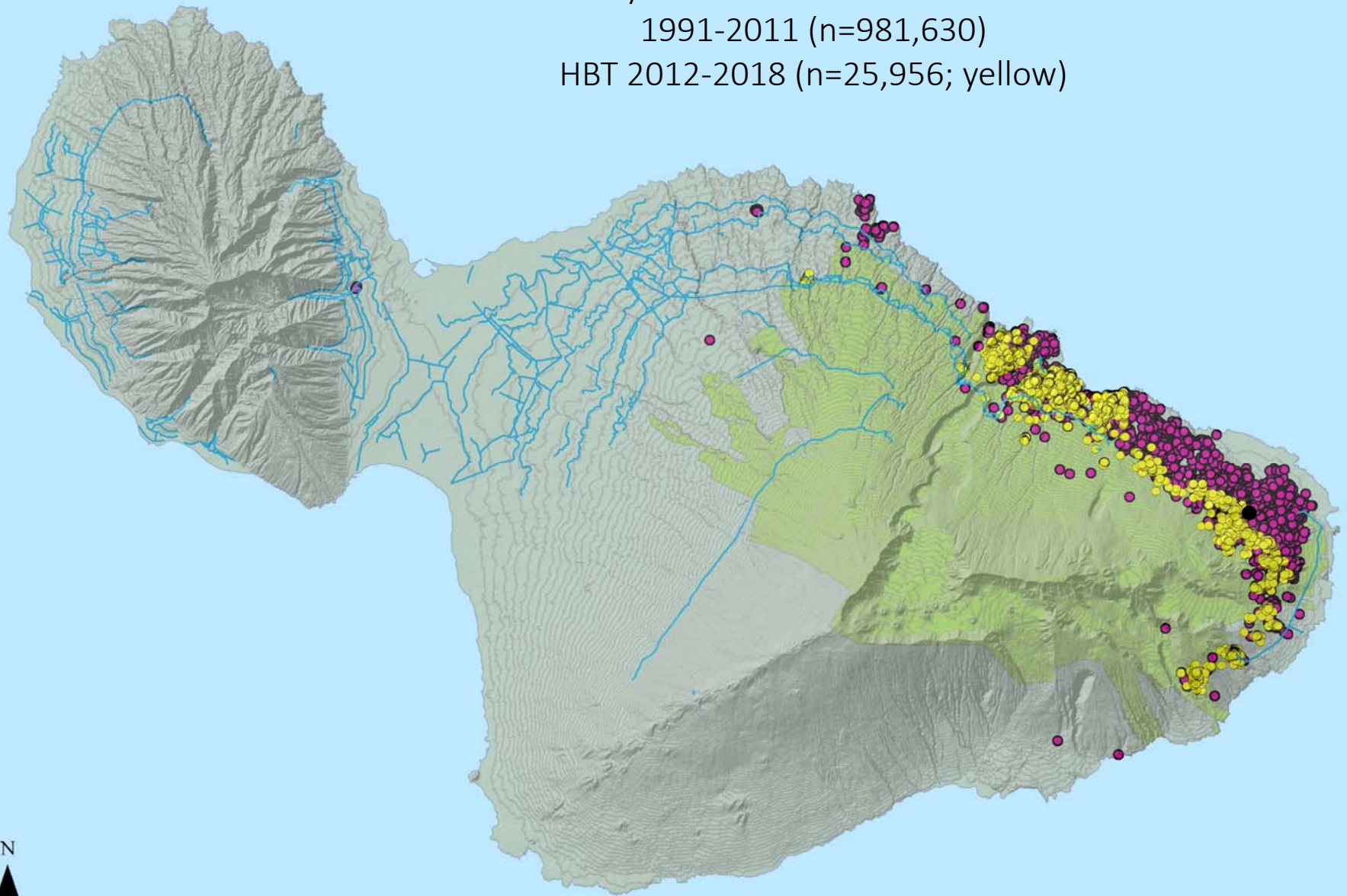
Low alt agl ( $\leq 30$  m) at slow search speeds (10 knots)

Operational flight time 80-90 min per cycle

Scan rate is  $\sim 0.5$ - $1.0$  sec pixel<sup>-1</sup> (100 m<sup>2</sup>)

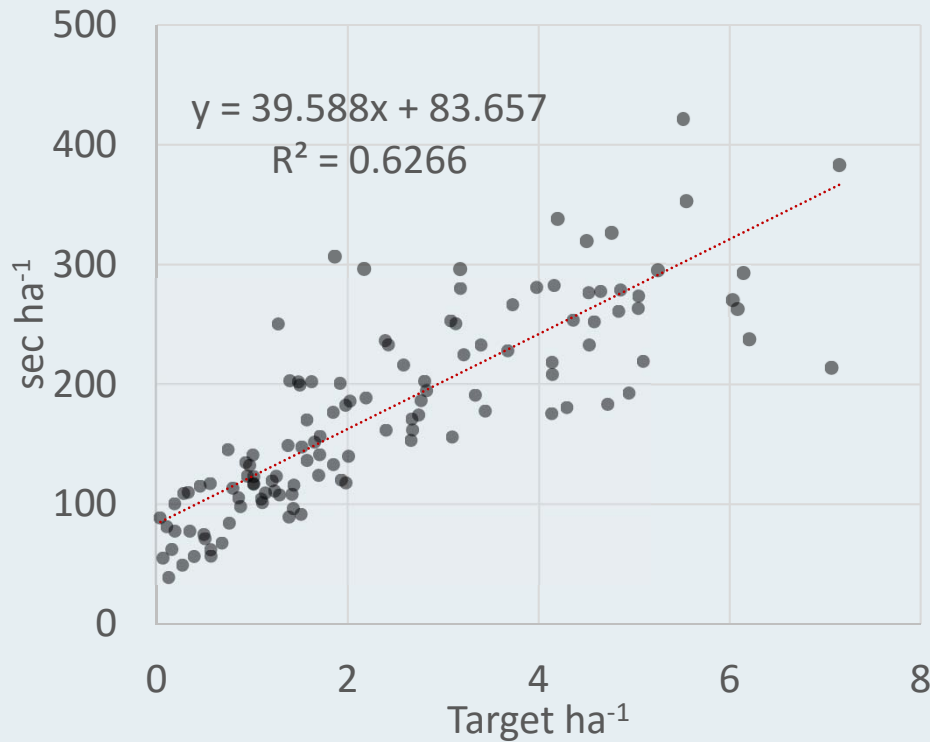


Invasion History of Miconia in the East Maui Watershed  
1991-2011 (n=981,630)  
HBT 2012-2018 (n=25,956; yellow)

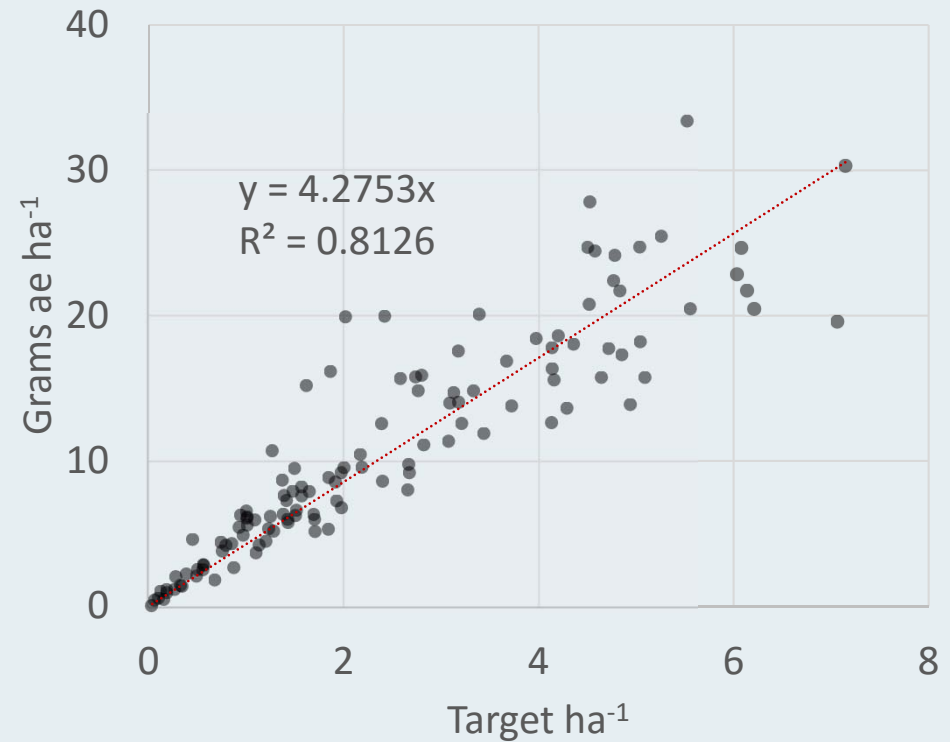


Variable costs of HBT operations determined by target density  
\$24.90 ha<sup>-1</sup> and \$20.71 tgt<sup>-1</sup>

Search Effort

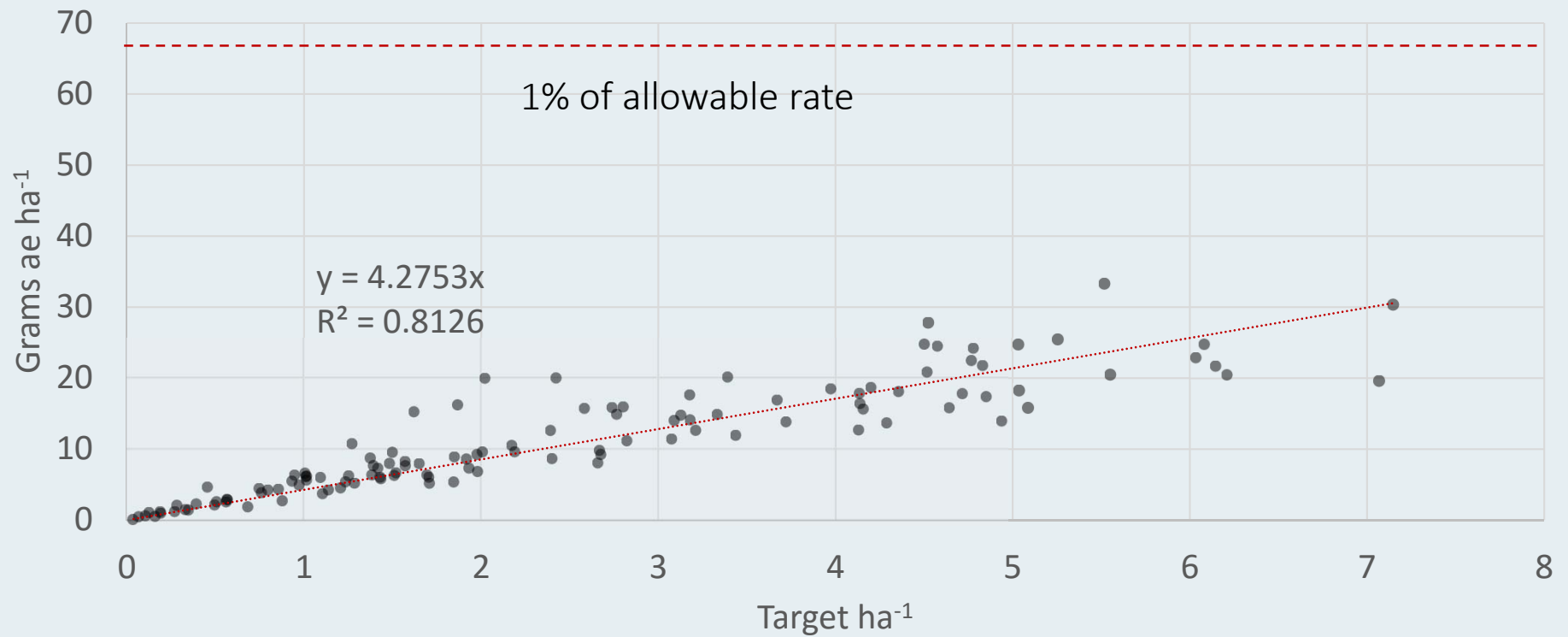


Herbicide Use Rate



- Search effort is a linear function of target density with search effort (EFT; y-intercept) equal to 83 sec ha<sup>-1</sup> = \$24.90 and target engage equal to 40 sec tgt<sup>-1</sup> = \$12.00
- Herbicide use rate is also a linear function of target density with average dose (slope) equal to 4.28 g ae (~22 projectiles) = \$6.71

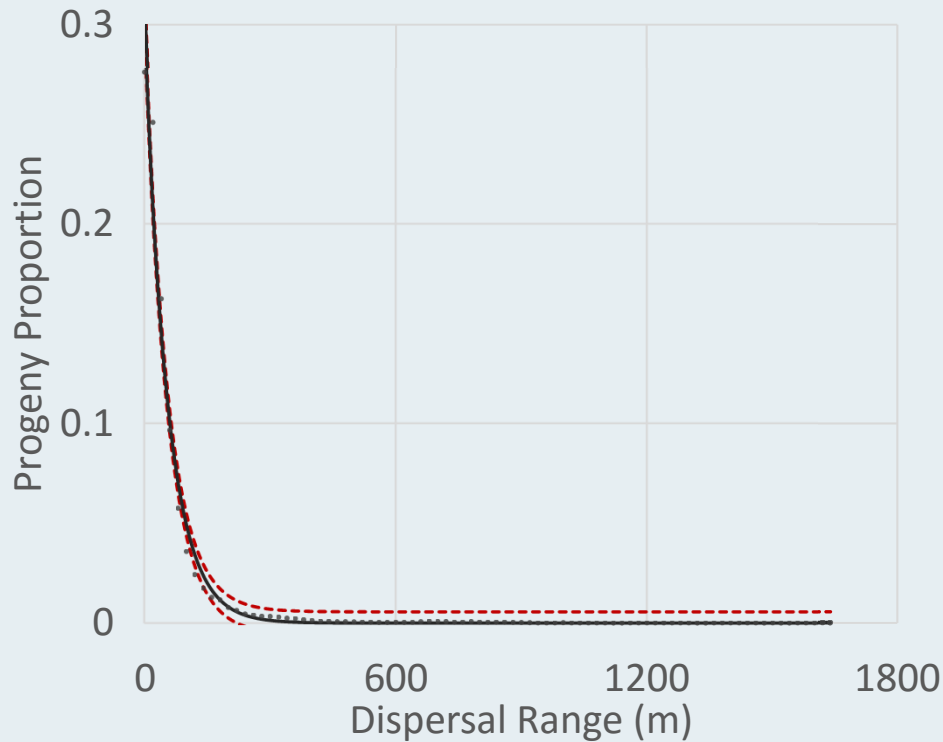
## HBT less than 1% of the max allowable use rate



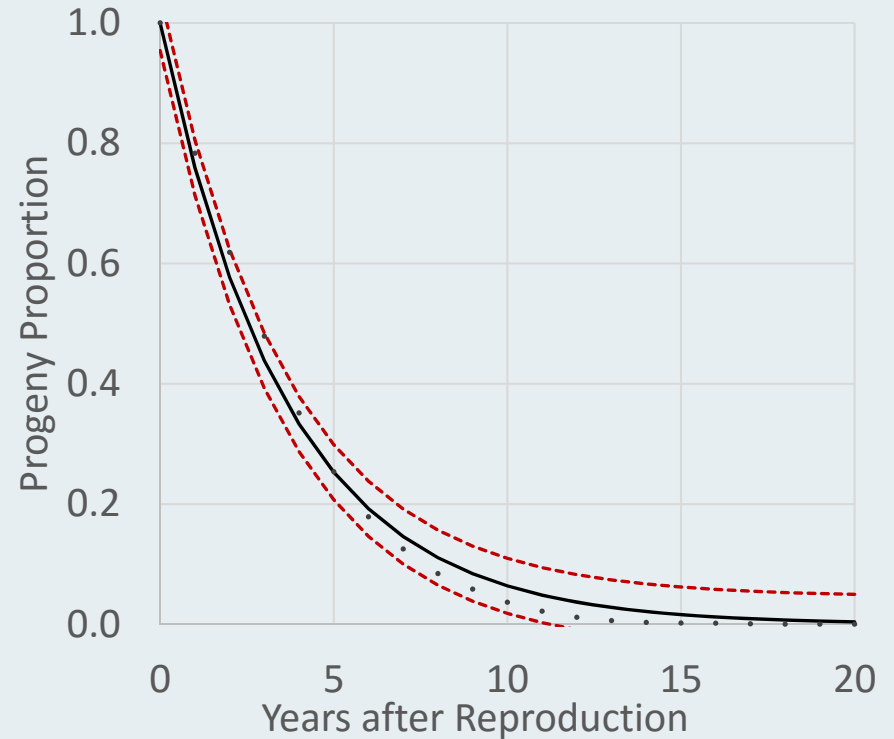
- Avg. herbicide use rate is 1/10<sup>th</sup> of 1% of the max allowable use rate

## Propagule Dispersal and Persistence Kernels of *Miconia*

Dispersal



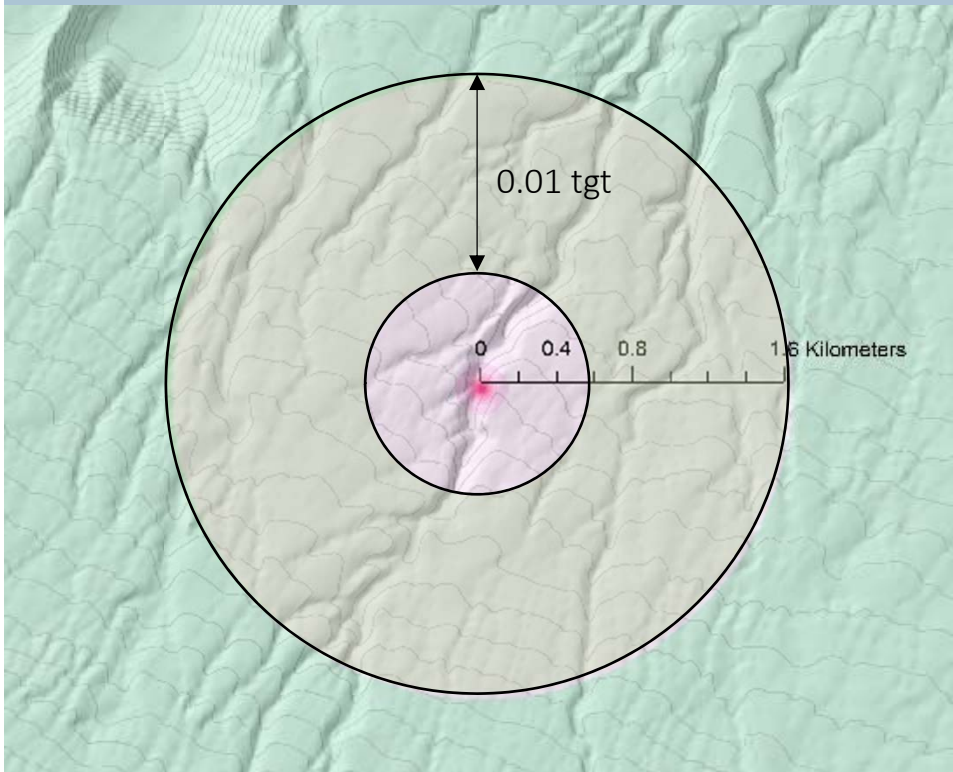
Recruitment



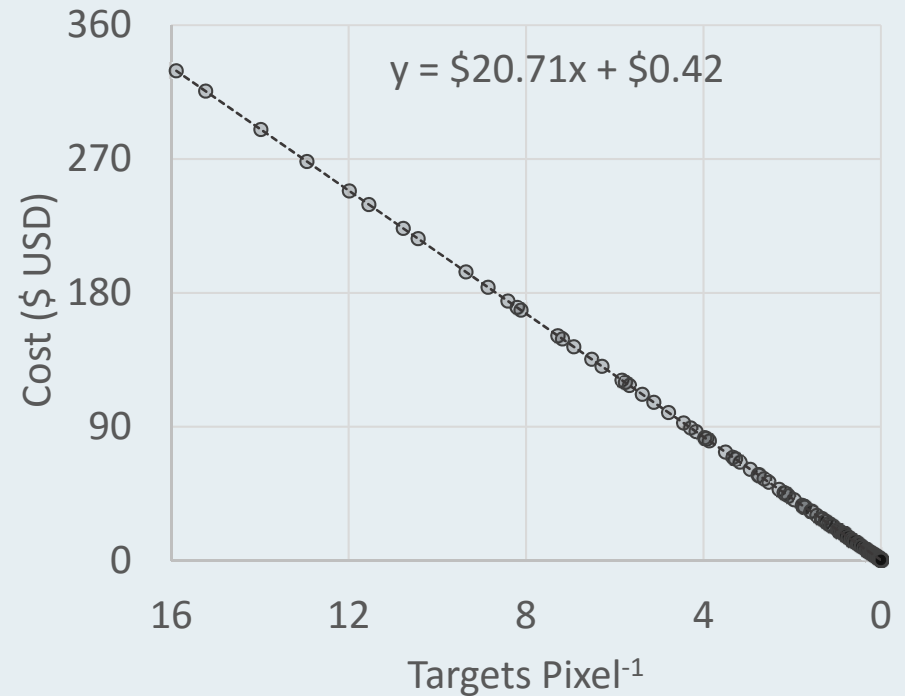
- Near analyses calculating the distance and time interval of progeny to maternal source.
- Dispersal kernels are leptokurtic with 99% of progeny within 587 m of the maternal source and rare long-distance events out to 1640 m.
- Seed bank depletion 90% in <10 yrs; extinction estimated between 20-30 years
- These estimates are highly congruent to dispersal estimates in AU (Fletcher and Westcott 2013) and seed bank longevity in Tahiti (Meyer 2010)

## Spatial Impact and Future Cost of an Incipient Miconia Colonizing New Range

Dispersal kernel



Density cost spectrum



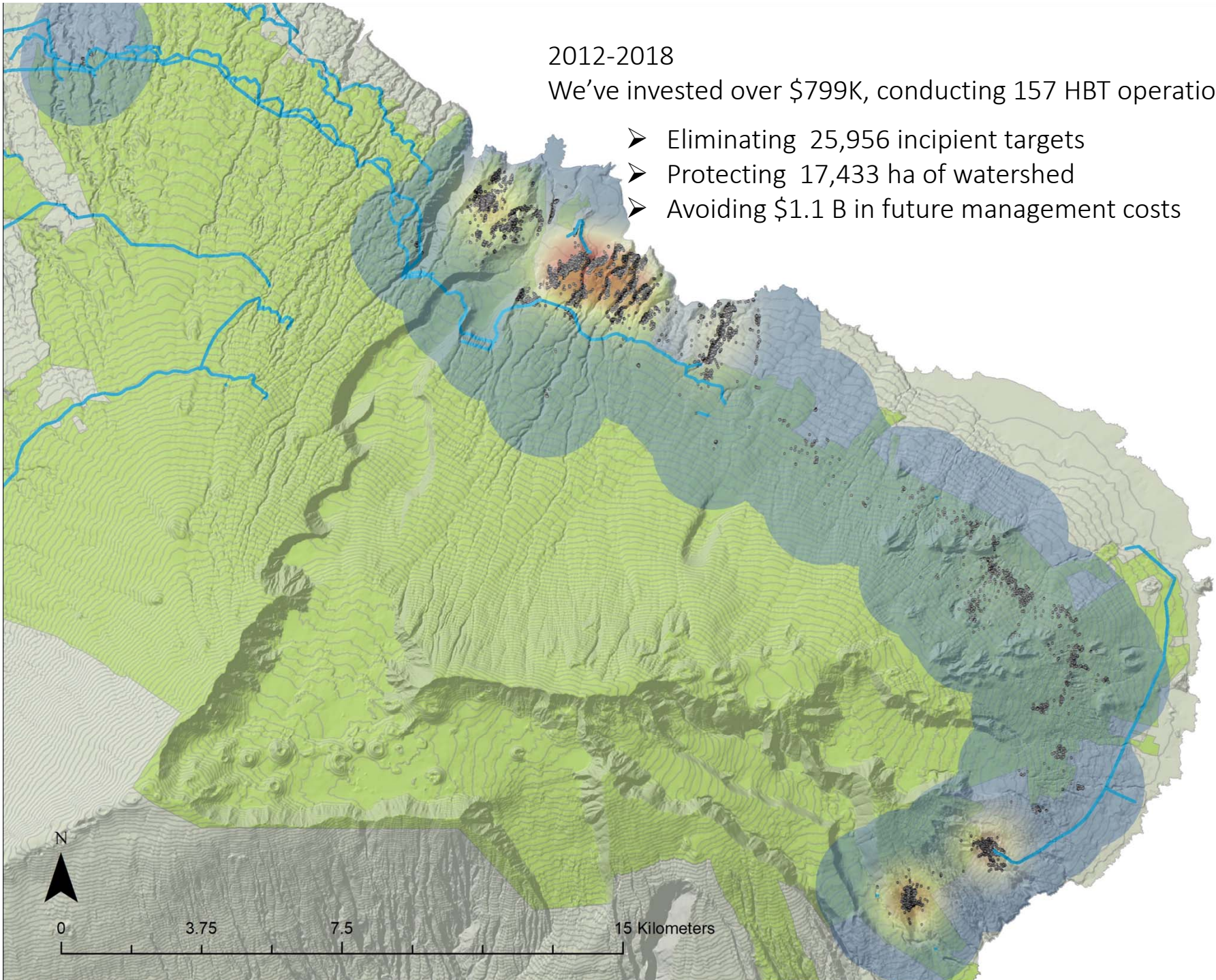
- Maximum dispersal distance creates a 841-ha impact area
- >90% of total cost searching for 1% of targets and expended in the first 10 years
- The highest recruit densities cost >\$300 pixel<sup>-1</sup>; effective search is \$0.42 pixel<sup>-1</sup>
- The total estimated cost \$42K to eradicate a new incipient population; 75% of total cost eliminating 1% of targets



2012-2018

We've invested over \$799K, conducting 157 HBT operations:

- Eliminating 25,956 incipient targets
- Protecting 17,433 ha of watershed
- Avoiding \$1.1 B in future management costs

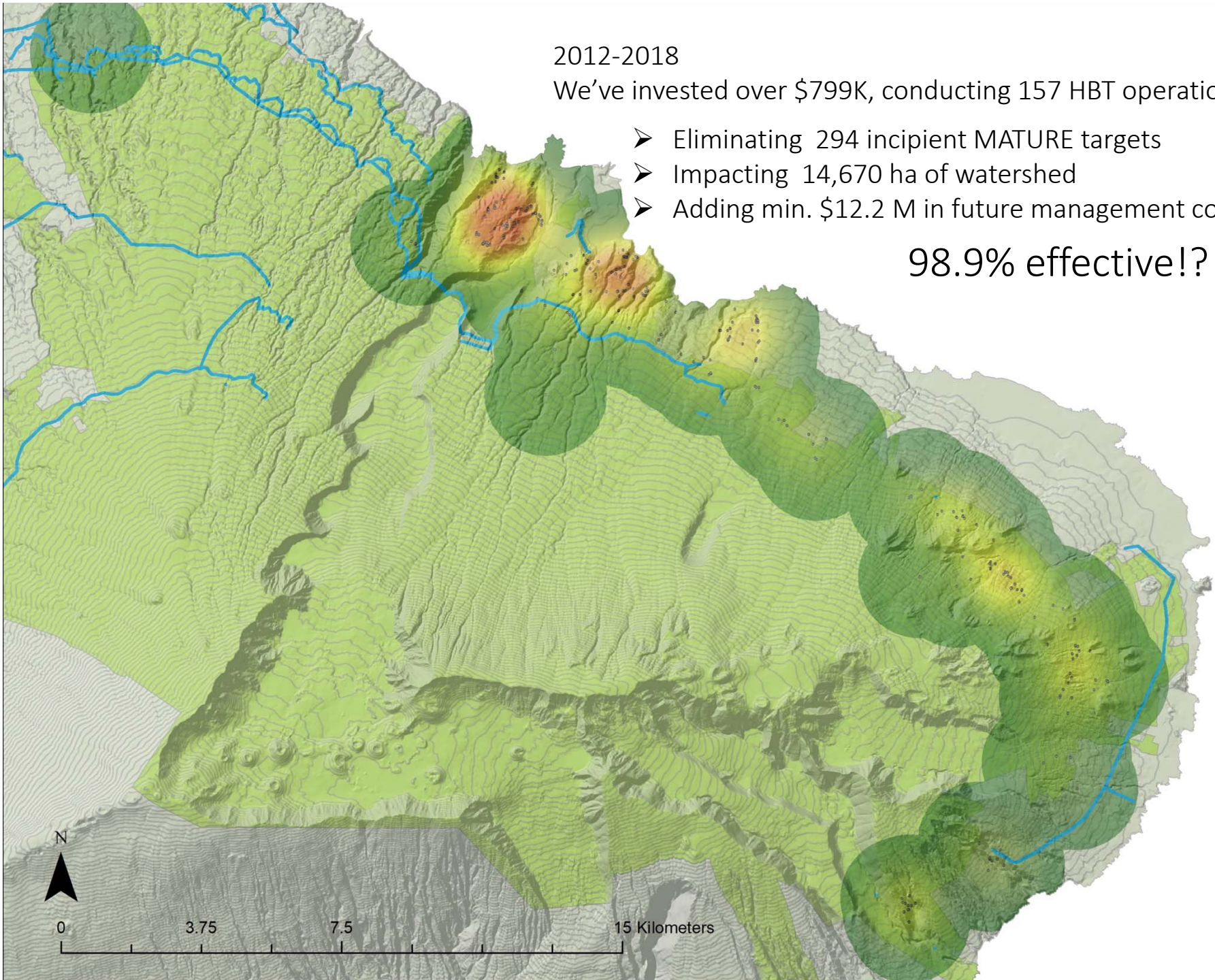


2012-2018

We've invested over \$799K, conducting 157 HBT operations:

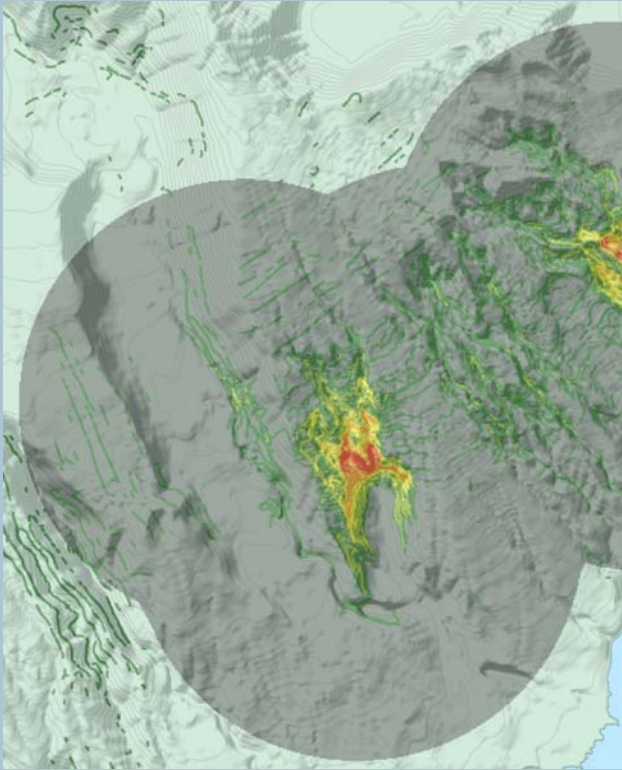
- Eliminating 294 incipient MATURE targets
- Impacting 14,670 ha of watershed
- Adding min. \$12.2 M in future management costs

98.9% effective!?!

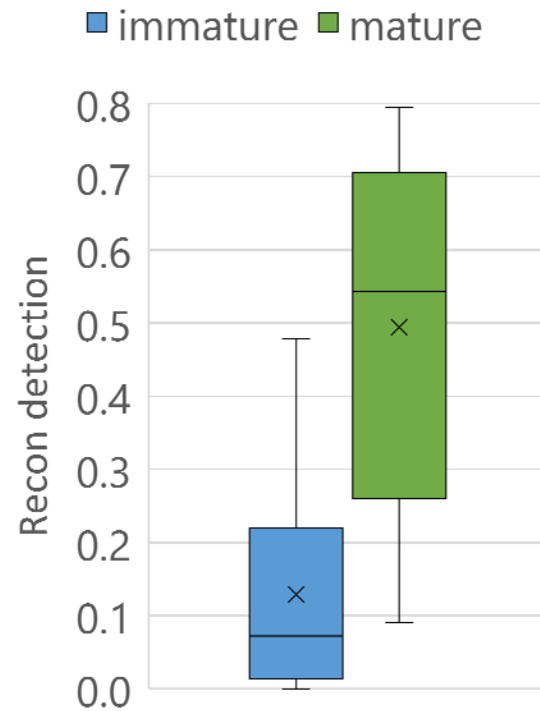


## Management to Achieve Containment

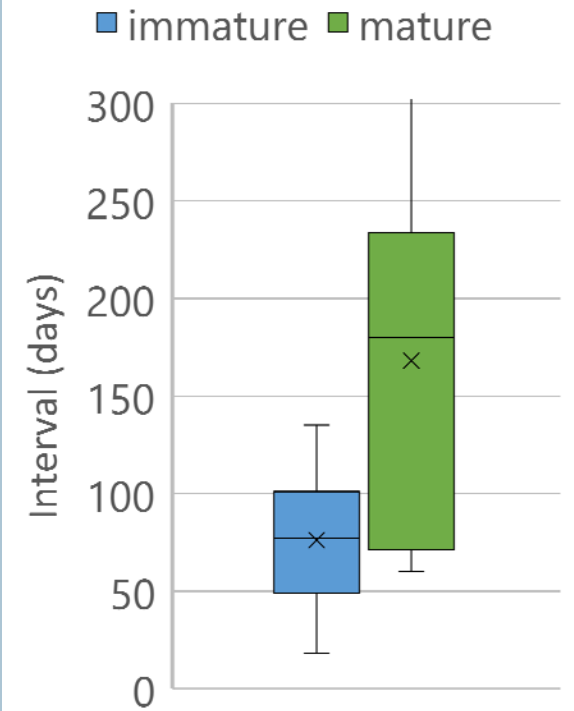
Search effort



Reconnaissance



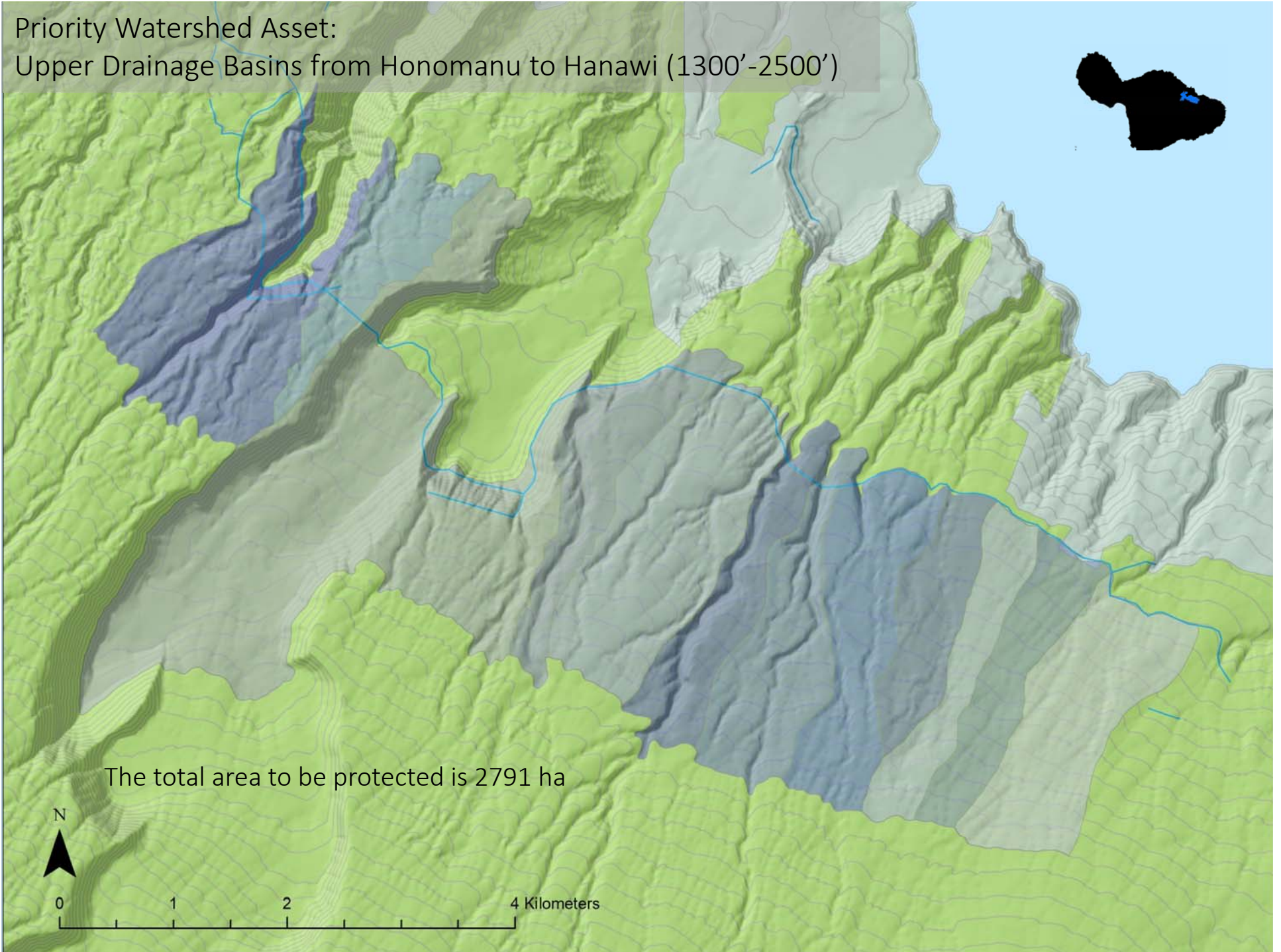
Search freq.



- Only ~12% of impacted area (grey) surveyed (i.e., protected)
- >50% of mature plants detected on the first intervention (reconnaissance)
- Time between interventions is 2x longer for mature detection i.e., 180 days

*Needs: 826 hrs recon and 672 hrs of search in the next 4 years = 4x acceleration = \$1.8M*

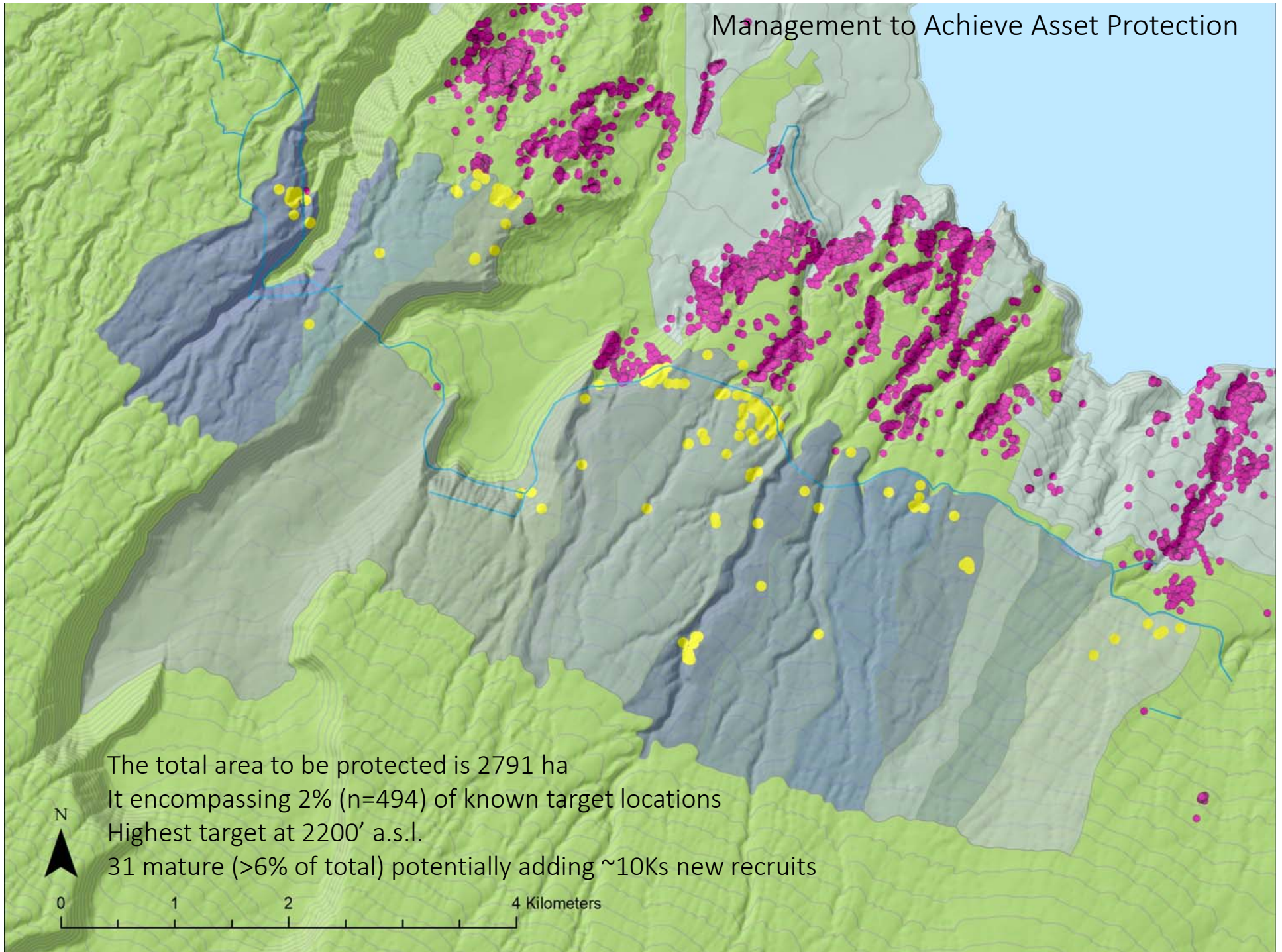
Priority Watershed Asset:  
Upper Drainage Basins from Honomanu to Hanawi (1300'-2500')



The total area to be protected is 2791 ha



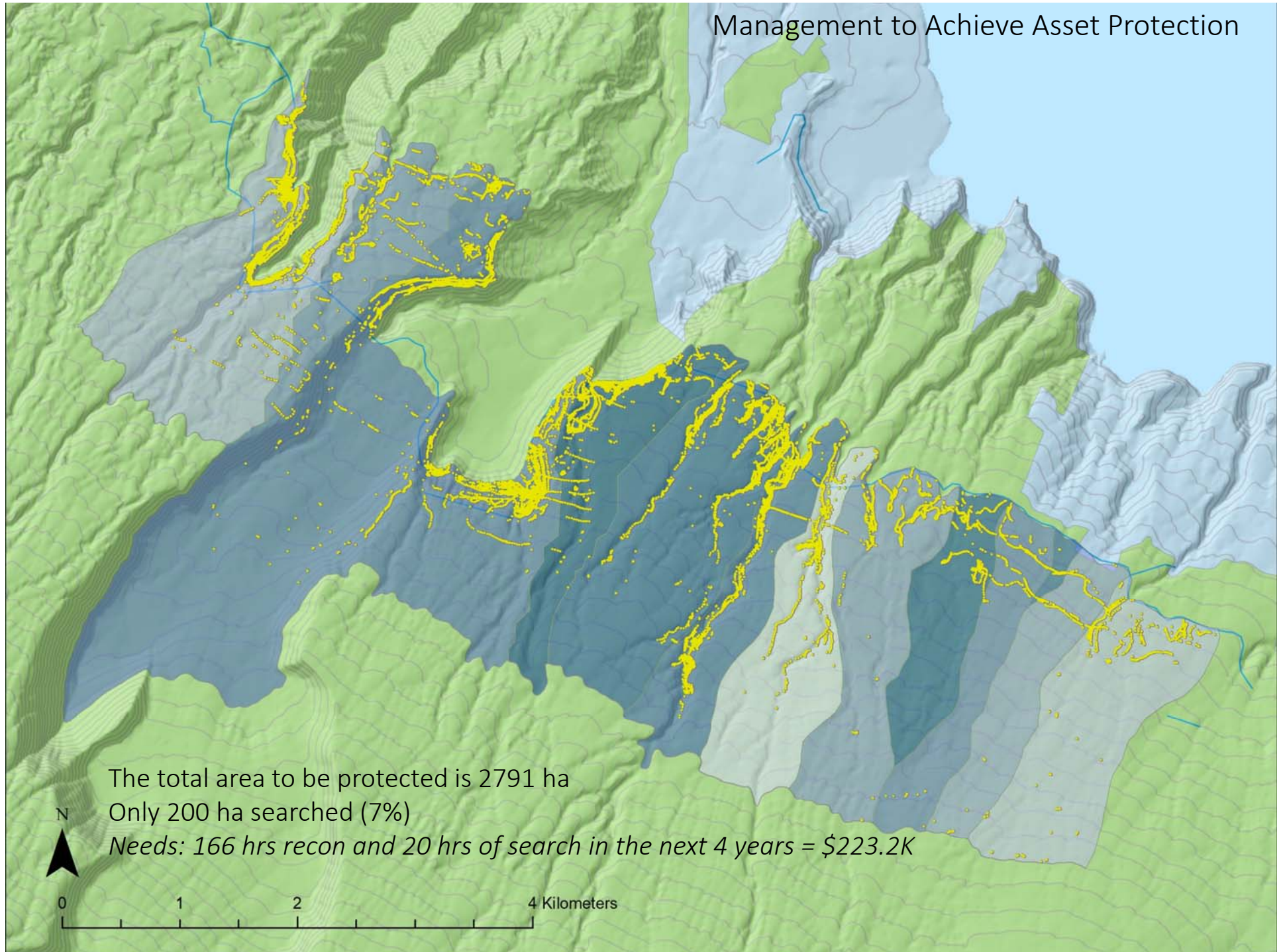
# Management to Achieve Asset Protection



The total area to be protected is 2791 ha  
It encompassing 2% (n=494) of known target locations  
Highest target at 2200' a.s.l.  
31 mature (>6% of total) potentially adding ~10Ks new recruits



# Management to Achieve Asset Protection



The total area to be protected is 2791 ha

Only 200 ha searched (7%)

*Needs: 166 hrs recon and 20 hrs of search in the next 4 years = \$223.2K*

N



0

1

2

4 Kilometers



## Review of concepts:

- Knowledge of phenology, fecundity and dispersal enhances our capacity to measure impact on the landscape and project long-term strategies
- The HBT platform encourages greater investment in surveillance with opportunities to eliminate incipient target populations (in real-time)
- Miconia is beginning to saturate major portions of its suitable habitat in the EMW.
- Protection of priority watershed assets appears to be the most cost effective option, but with substantial trade-offs.

# Partnerships Are The Only Way To Do This !!!

Collaborators:



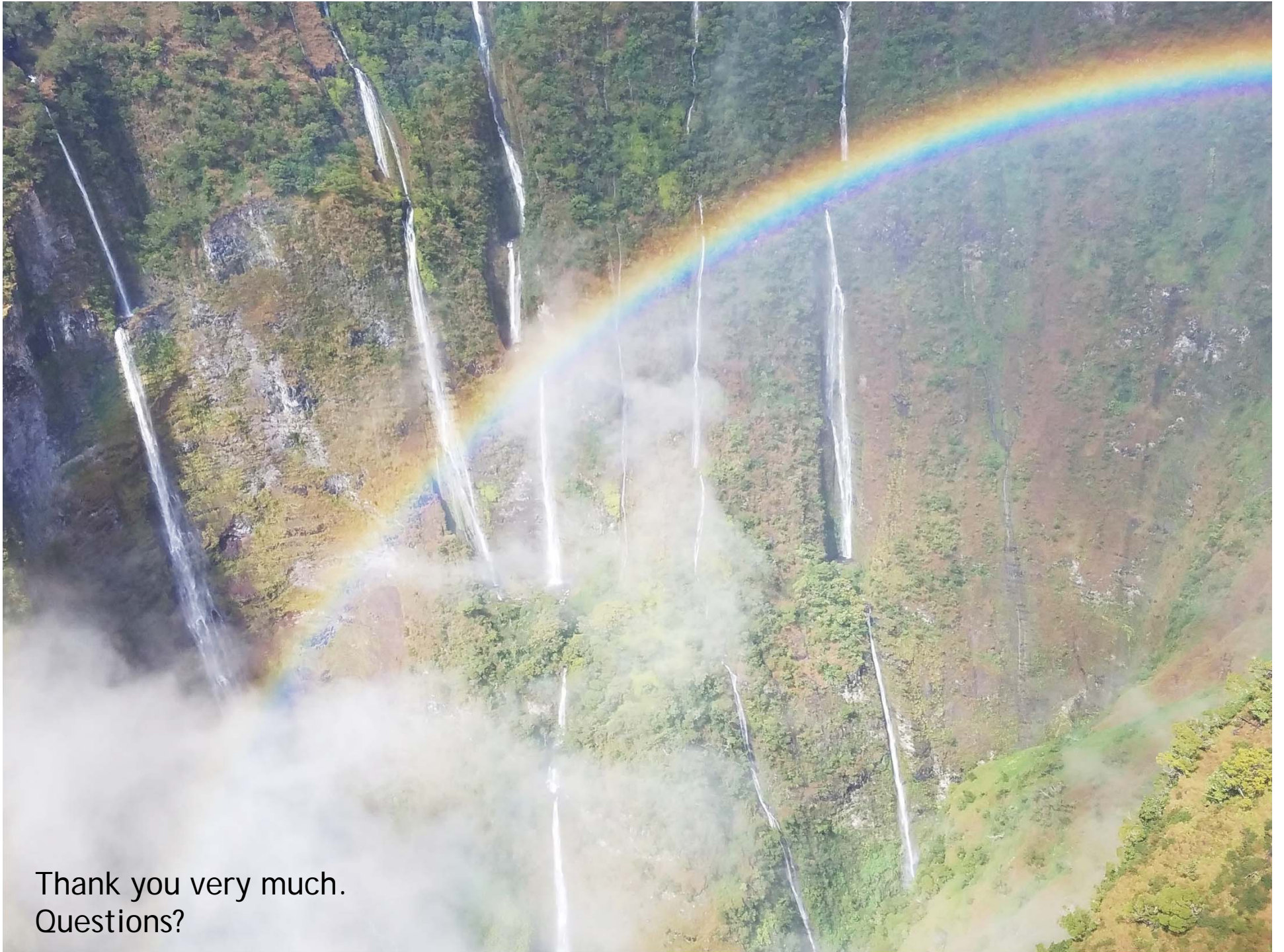
This project has been supported in part by:



- US Forest Service Special Technology Development Program Award R5-2012-01
- USDA Hatch Act Formula Grant project 132H
- Hawaii Invasive Species Council Research and Technology Grant Program
- Maui County Department of Water Supply and the Office of Economic Development via collaboration with the Maui Invasive Species Committee

*MAHALO*





Thank you very much.  
Questions?